ADDRESS MANAGEMENT IN MOBILE IP ENVIROMENTS

5   [Field of the application]

The present application relates to a data unit processing
entity in a data unit transmission network and to a control
method for such a data unit processing entity.

10

[Background of the invention]

In the field of data communication, it is known to provide
data unit transmission networks. Data that needs to be
15   transported over such a data unit transmission network is
divided into individual data units, and each data unit
carries a routing address that is used by network nodes for
sending the data unit to its intended destination. The
handling of such data units is typically performed in
20   accordance with an appropriate protocol, e.g. the Internet
Protocol (IP). It is noted that such data units may carry
different names in the context of different protocols, such
as packet, protocol data unit, segment, frame, etc. In the
present description and claims, the term "data unit" is used
25   generically to describe any such fragment of data that is
being transported over an appropriate network.

If all network nodes of a data unit transmission network are
immobile and are always connected to the overall network via
30   the same links, then there is no problem in routing data
units to intended receiving nodes, because the routing
address serves both to identify and to locate the receiving
node. However, the situation becomes more complicated if at
least some nodes that can access the data unit transmission
35   network over more than one link. For example, a node could be
capable of moving and of accessing the network over various
links depending on location. Such a node capable of accessing

CONFIRMATION COPY

the network over more than one link will therefore be
referred to as a mobile node in the present description and
claims. However, it is to be noted that the term "mobile
node" relates to any node capable of accessing the network
over more than one link, regardless of whether the node is in
fact physically mobile. In other words, the term "mobile
node" also covers nodes that are neither physical mobile nor
moving, as long as they are capable of accessing via more
than one link. As an example, a mobile node could therefore
be a stationary computer that is equipped with a wire line
LAN connection, a wireless LAN capability and a GPRS radio
capability, such that it could access a network (e.g. the
Internet) over these three different links.

The situation of nodes that can access a network over more
than one link requires additional routing capabilities.

In connection with work on expanding the capabilities of the
Internet protocol, request for comments 3220 that relates to
version 4 of the Internet Protocol (IPv4) describes the use
of two types of routing addresses, a so-called home address
for identifying a node and a so-called care-of address for
forwarding of data units to mobile nodes. The home address
(HoA) is an example of the general concept of an identifying
address (IA), and the care-of address (CoA) is an example of
the general concept of a forwarding address (FA).

The term "mobile node" therefore refers to such that nodes
that can have a plurality of forwarding addresses
simultaneously.

In a generalised network operating in accordance with an
appropriate routing protocol (RP), the network nodes are
arranged to distinguish between the IAs and the FAs in a data
unit to be forwarded. It is noted that the term "routing
protocol" (RP) as used in the present description and claims
is generic to describe any protocol suitable for allowing the

3

routing of data units over a plurality of network nodes. IP
is an example of such a general routing protocol.

In a data unit transmission network that uses identifying
addresses and forwarding addresses, one may provide special
data unit processing entities or agents that perform a
decision operation for determining a forwarding address on
the basis of an identification address. It is noted that the
term "entity" or "agent" as used in the present specification
and claims refers to a functional element that is capable of
performing a certain function. An entity or element may be
located in a single place, e.g. in a node, but it can also be
distributed over several locations, e.g. several nodes or
other network elements.

The data unit processing entity of this type comprises a
decision part for setting a forwarding address in a received
data unit depending on the identification address set in the
received data unit, by accessing a memory that contains
decision data, where the decision data comprises one or more
forwarding addresses associated with identification address.
As an example, in the present proposals for developing IP,
i.e. for version 6 (IPv6), the use of a so-called home agent
is proposed. A home agent receives data units that contain
the home address (i.e. the identifying address), and on the
basis of rules and parameters stored in a so-called binding
cache performs a so-called binding operation, i.e. determines
the care-of address for the given home address. In the
present discussion of further developing IP networks using
mobile nodes, i.e. in the discussion for Mobile Ipv6 (MIPv6),
it is considered that the mobile node can have multiple care-
of addresses. It can re-route between different care-of
addresses by indicating to appropriate agents in the network
which care-of address to use.

The method of managing the decision data is performed by
letting the mobile node send so-called binding updates to the

home agent or to the so-called corresponding nodes. A
corresponding node is a node with which the mobile node is in
communication, and in the course of this communication, the
mobile node can simply indicate to the corresponding node,
which care-of address to use. The basic principle is that the
home agent and corresponding nodes can only have one care-of
address listed in the binding cache. It is the mobile node
that decides to which care-of address data is directed that
is destined for the home address (via the home agent), and it
can determine for each corresponding node to which care-of
address the corresponding node should send. The principle
therefore is that each home agent or corresponding node only
has one of the possible care-of addresses indicated in its
binding cache.

In connection with mobile Ipv6 a system called NOMADv6 has
been proposed, which comprises filters for mobile Ipv6
bindings. NOMAD allows a mobile node that has a plurality of
care-of addresses to register multiple binding updates at any
appropriate binding agent (e.g. home agent, correspondent
node or a so-called mobility anchor point) and associate
these different bindings with a filter. The filter allows to
direct different flows to different care-of addresses based
on the Traffic Class field in the IPv6 header, the Flow Label
field in the IPv6 header, the Protocol Extension field in the
IPv6 header, which identifies the type of higher layer
protocol being used, the Source Address (or source address
prefix), a range of Source Port or Destination Port numbers
in the protocol header, or the value of a certain data region
within the IPv6 packet.

A further concept known in connection with mobile IPv6 is the
use of bicasting, i.e. of allowing a home agent to
temporarily have bindings to two care-of addresses for the
same home address. While such bindings are simultaneously
active, every packet is replicated and a copy is sent to each
care-of address.

[Object of the invention]

The object of the invention is to further improve the
5   capabilities of a system that uses identifying addresses and
forwarding addresses.

[Summary of the invention]

10 The object is achieved by a data unit processing entity as
described in claim 1 and a method of controlling a data unit
processing entity as described in claim 8. Advantageous
embodiments are described in the dependent claims.

15 In accordance with the present invention, the data unit
processing entity contains a management part that provides a
network control function with access to the decision data
memory independently of any access provided to one or more
mobile nodes. Typically, the management part will also
20 provide an interface to the decision data for mobile nodes,
but this is not necessary. In other words, the decision data
that is used by a decision part of the data unit processing
entity for selecting a forwarding address on the basis of an
identifying address contained in a data unit, can be changed
25 by a network control function independently of the changes
that may be performed by or at the request of any mobile
nodes.

This concept provides great advantages. It allows the
30 combination of mobility management at the level of the
routing protocol (RP) of the data unit transmission network
with network control operations that take into account
parameters and requirements used in the overall network
management. For example, if the mobile nodes connect to the
35 data unit transmission network over a variety of radio links,
then the management of radio links can be brought into
association with the mobility management performed by the

data unit processing entity that determines a forwarding address on the basis of an identifying address. In other words, aspects of radio link management, such as utilization, over-loading, congestion etc. can be taken into account by a

5 network control function that in turn has access to the decision data memory of the data unit processing entity, in order to appropriately update the decision data. For example, it is possible that while a mobile node has indicated to the data unit processing entity that it wishes to receive data

10 units over a forwarding address that is associated with one radio link of a plurality of available radio links, the network control function may override that request by writing a different forwarding address into the decision data, e.g. because the radio link associated with the forwarding address

15 selected by the mobile node is over-loaded while another available radio link is under-utilized. With the concept of the present invention, it is especially possible to perform a network controlled handover procedure for a given mobile node, i.e. a handover procedure in which the network

20 initiates the handover and/or decides on the initial and final communication links.

According to a preferred embodiment of the invention, the management part provides independent access to the decision

25 data for a plurality of control functions. This has the particular advantage of a decentralized control over the management of the decision data, and consequently over the decision procedure itself. All of the various control functions have at least partial access to the decision data,

30 such that each of the control functions is involved in the control process for setting forwarding addresses. This provides great flexibility and many new degrees of freedom in overall data unit handling in comparison with a centralized system like in the prior art, in which only one control

35 function controls the decision data.

7

[Brief description of Figures]

In the following, the present invention will be described by
referring to specific detailed embodiments which are not
5   intended to be limiting, and by reference to figures, where

Fig. 1   shows a schematic representation of a data unit
             transmission network comprising a plurality of
             nodes;

10
Fig. 2   shows a schematic representation of a data unit
             carrying an identifying address and a forwarding
             address;

15   Fig. 3   shows a further example of a data unit carrying an
             identifying address and a forwarding address;

Fig. 4   shows a schematic block diagram of an embodiment of
             the invention;

20
Fig. 5   shows a flow chart for describing an example of a
             decision procedure for setting a forwarding address
             on the basis of an identifying address;

25   Fig. 6   shows a flow chart of an example of a management
             procedure for managing the decision data memory;

Fig. 7   shows a flow chart of a further example of a
             management procedure for managing the decision data
30   memory; and

Fig. 8   shows a schematic block diagram of another
             embodiment of the invention.

35

[Detailed description of embodiments]

In the following description and detailed embodiments,
reference will sometimes be made to the Internet Protocol

5   (IP) and presently discussed modifications thereof, such as
IP version 6 (IPv6) and Mobile IPv6 (MIPv6). The Internet
Protocol and its modifications are a preferred application of
the concepts of the present invention, but the present
invention is by no means restricted to IP or its

10   modifications, or even to network layer protocols in general.
Much rather, the present invention can be applied in the
context of any data unit transmission network that uses
identifying addresses and forwarding addresses. For example,
the invention can also be applied in the context of MPLS

15   (Multi Protocol Label Switching), which is a protocol
situated below IP, i.e. below the network layer, but in
effect above the link layer.

Fig. 1 shows a schematic representation of a data unit

20   transmission network 10 that comprises network nodes 101-112.
Among these network nodes there are routing nodes 101-109,
which are arranged to route data units over the data unit
transmission network 10 in accordance with an appropriate
routing protocol that will generically be abbreviated as RP.

25   As indicated above, the routing protocol RP may be any
appropriate network layer protocol, such as IP or a
modification of IP, but may also be a routing protocol that
is situated at a different layer, such as MPLS.

30   The network 10 furthermore comprises end nodes 110, 111 and
112, i.e. nodes that are terminals of the network. Nodes 110
and 111 are mobile nodes, which communicate with appropriate
access nodes 106, 108 or 109 in wireless fashion. On the
other hand, end node 112 is a fixed node that is fixedly

35   connected to node 107, e.g. by one fixed wire-line link. It
is again noted that the present invention is not restricted
to any specific type of mobile node. As such, the mobile

nodes can access the data unit transmission network in any
way suitable for communication over a plurality of access
links, e.g. radio, infrared or even by (possibly movable)
wire-line connections.

5

For example, it is possible that a mobile node can access the
data unit transmission network over a first type mobile phone
connection (e.g. via GSM), a second type mobile phone
connection (e.g. via UMTS) and a wireless local area network
10   (W-LAN). Each of these different access possibilities is then
associated with its own forwarding address, although the
mobile node only has one identifying address. Typically, the
individual forwarding addresses will also be associated with
their own access node, e.g. when considering the example of
15   Fig. 1, network node 108 will handle data units carrying a
first forwarding address for mobile node 111, while access
node 106 will handle data units carrying a different
forwarding address for mobile node 111.

20   The network nodes 101-112 are capable of distinguishing
between an identifying address IA and a forwarding address FA
in data units that are being transmitted over network 10.
This can be achieved in any suitable or desirable way, e.g.
by providing for a specific structure of the data units, such
25   that the identifying address and the forwarding address are
to be found at respectively designated fields of the data
units. This shall be explained with the examples of Figs. 2
and 3.

30   Fig. 2 schematically shows a data unit 20 that consists of a
basic data unit 21 that has its own header 23. For example,
this basic data unit 21 can be a standard IP packet, where
header 23 contains a field 24 for the standard IP address. In
this case, the standard IP address is the identifying
35   address. In accordance with the routing protocol RP employed,
an additional header 22 can be added, which comprises a
designated field 25 for a forwarding address.

Fig. 3 shows a different scheme where a data unit 30 has a
single header 31, which comprises a first field 32 for
holding the identifying address IA and a second field 33 for
5   holding the forwarding address FA.

In any case, the network nodes 101-112 are capable of
appropriately reading the data units and identifying the
respective addresses.
10
Fig. 4 shows a schematic representation of an embodiment of
the present invention. Reference numeral 4 relates to the
data unit processing entity, which comprises a decision part
41, a decision data memory 42 and a management part 43. The
15   decision part 41 is arranged to set a forwarding address FA
in a received data unit that is to be forwarded. The
operation of the decision part 41 depends on the identifying
address set in the received data unit that is to be
forwarded, and on the decision data stored in association
20   with the given identifying address in the decision data
memory 42. The decision data comprises one or more forwarding
addresses FA, which the decision part may select.

The management part 43 is arranged to provide an interface to
25   the decision data memory 42 for modifying the decision data
stored therein. The interface is arranged to provide one or
more mobile nodes access to the decision data memory 42 for
updating the decision data. In the example of Fig. 4,
reference numeral 47 represents a mobile node, which
30   comprises a control function 50 capable of communicating with
the management part 43, in order to modify the decision data
stored in decision data memory 42. For example, the control
function 50 can send update requests to the management part
43 indicating that the mobile node 47 would like to change
35   from a forwarding address FA1 that is associated with radio
link 52 to a different forwarding address FA2 that is
associated with radio link 53. In the example of Fig. 4,

reference numeral 45 relates to a first access node that
mobile node 47 may employ and reference numeral 46 to a
second access node that mobile node 47 may employ. Reference
numeral 44 is a given node that sends RP data units to mobile

5   node 47. For example, it can be a correspondent node in
accordance with IPv6. The data unit processing entity 4 is an
appropriate agent for identifying and inserting forwarding
addresses. As such, it can be associated with a given node,
such as the node 44, or it can be located at a specific node

10   associated with the mobile node 47, i.e. as a type of home
agent at the node that receives data units that only carry
the identifying address IA of mobile node 47, such that these
data units may receive a forwarding address FA that allows
routing of the data units to the intended destination, i.e.

15   mobile node 47.

Equally, the data unit processing entity 4 may be provided at
a designated node of the network, i.e. a type of mobility
anchor point, that is designated to handle data units that

20   lack a forwarding address.

In the example of Fig. 4, the entities communicate at the
level of the routing protocol RP, i.e. are peers of this
protocol. As indicated, the access nodes 45 and 46 are also

25   peers, but the underlying link protocol LP is different for
the two different types of mobile access. For example, the
link 52 can be governed by a link layer protocol for a mobile
phone connection (e.g. for GSM, GPRS or UMTS), while link 43
may be governed by a link protocol for W-LAN.

30
In accordance with the present invention, the management part
43 furthermore provides an interface for a network control
function 51, such that the network control function 51 can
access the decision data in decision data memory 42

35   independently of any access provided to one or more mobile
nodes, such as mobile node 47.

12

Function 51 can be any type of network control function, e.g.
a radio resource management function for radio links. For
this purpose, the network control function 51 can communicate
with radio control functions 48, 49 that are respectively

5   associated with radio links 52 and 53. In this way, the
network control function 51 can e.g. be a multi-radio
resource management (MRRM) function.

Such an arrangement has the particular advantage that a

10   coordinating management of radio resources for different
access technologies can be combined with the mobility
management at the level of the routing protocol RP. It is
noted that one of the decisive aspects of the basic routing
at the level of the routing protocol RP is that it is

15   independent of any particular underlying access technology.

In Fig. 4. the connections between the network control
function 51 and the management part 43 is shown as a dotted
line, just like the connections between the control functions

20   48, 49 and the network control function 51. The connections
among the control functions and between a control function
and the management part can be provided in any suitable or
desirable way. In other words, they may make use of data
units that adhere to the routing protocol RP, or the

25   connections can be via separate, dedicated control signalling
connections. In this way, the network control function 51 may
be provided in one or more of the network nodes, or can be
provided separately from the network nodes in a dedicated
control architecture.

30
It is noted that although the control functions 48 and 49
shown in Fig. 4 communicate with the network control function
51, which in turn may access the decision data memory 42 via
the interface of the management part 43, it is equally

35   possible that the control functions 48, 49 directly
communicate with the management part 43. This is shown in the
embodiment of Fig. 8, which uses the same reference numerals

as Fig. 4, such that a repeated description of the
corresponding elements is not necessary.

In the example of Fig. 8, the control functions 48, 49, 50
5   and 51 each have independent access to the decision data.
Therefore, each is involved in the decision procedure for
determining forwarding addresses on the basis of an
identifying address. This leads to a highly flexible
decentralized control structure for the management of the
10 forwarding addresses at the level of the RP.

In general, the data unit processing entity of the present
invention is such that the interface provided by the managing
part 43 provides a plurality of control functions with access
15 to the decision data memory 42. One or more of this plurality
of control functions may be located in one of the mobile
nodes, such as the control function 50 located in mobile node
47.

20 Fig. 5 shows an example of a decision procedure setting a
forwarding address in a received data unit that is to be
forwarded. In step S51, the identifying address IA is read in
the received data unit. Then, in step S52, the decision
procedure looks into the decision data memory 42, in order to
25 retrieve the decision data associated with the identifying
address IA. The retrieved decision data is then processed to
obtain a forwarding address FA. Finally, the obtained
forwarding address FA is set in the data unit, see step S53.

30 It is noted that the decision data may have any suitable or
desirable form. Preferably, the decision data comprises
decision rules and decision parameters. These decision rules
and decision parameters can be stored in association with an
identifying address, e.g. in the form of tables referenced
35 via the identifying address IA.

The decision rules can e.g. have a simple "if-then" form,
such as "if the higher layer protocol is X, then select
forwarding address FA 1" and "if higher layer protocol is Y,
then select forwarding address FA 2". For example, X may
5   stand for UDP and Y for TCP. Decision parameters can be
values to which rules refer, such as "if data unit size is
below parameter Z, then select forwarding address FA 1, else
FA 2", where "parameter Z" is a variable that refers to a
value stored in the decision data memory, and the management
10   part 43 may allow the external control functions to update
this parameter. Another example for rules is that they depend
on such parameters as the data rate or delay along a given
link, such as "if delay exceeds Th on link with FA 2, then
set select forwarding address FA 3", where "delay" is
15   provided by a control function associated with the FA 2 link,
and Th is an adjustable threshold parameter.

The rules may also be more sophisticated, e.g. depend on one
or more predetermined cost functions. A rule could then e.g.
20   be "Set forwarding address such that Cost_function_A is
minimum", where Cost_function_A is a predetermined cost
function. The cost functions may evaluate "cost" in terms of
one or more of monetary value, energy, network load, delay,
throughput, data rate, quality of service (QoS), or any other
25   suitable or desirable measure. Such measures may specifically
be associated with link resources, and relate to time slots,
codes, frequencies, carriers, transmission power, etc.

Rules may also depend on user behaviour, for example on the
30   mobility behaviour of the user of a mobile node that is
moving. If it is e.g. determined that a user is moving
quickly or consistently, as measured by an appropriate
parameter, then a rule could be present for avoiding the
setting to a forwarding address that would require an
35   expected handover very soon, e.g. a forwarding address
associated with a micro-cell from which it can be expected
that a fast moving user will soon exit. In other words, "if

motion_parameter exceeds Th_m, then do not set FA 4", where
motion_parameter represents a parameter that indicates the
user's degree of motion, and Th_m is an adjustable threshold.

5   The access to the decision data memory may be such that only
    parameters can be updated, or only rules, but it is
    preferable that the access is such that both rules and
    parameters may be changed. For example, in the context of the
    example of Fig. 8, access could be such that the control
10 functions 48, 49 only access and change parameters (such as
    e.g. delay and data rate values associated with their links),
    whereas control function 51 only accesses and amends rules.
    Control function 50 could in turn be allowed to access all
    rules, parameters that relate to the mobile node, but not
15 parameters that e.g. relate to links 52, 53. This example
    provides the advantage of a control scheme in which the
    possibly very different time scales of different control
    functions are very simply integrated. Namely, the control
    functions 48, 49 will typically send update requests much
20 more often than the mobile node, due to the possibly rapidly
    changing circumstances at these links. Nonetheless, this does
    not lead to any problems.

    In summary, one or more of the multiple control functions
25 with which management part 43 communicates, are network
    resource management functions, e.g. for managing radio
    resources.

    Figs. 6 and 7 show examples of management procedures for
30 changing the decision data in the decision data memory 42. In
    Fig. 6, the procedure begins with step S61, in which it is
    determined whether an update request (UR) has been received
    from a mobile node (MN). Such an update request may originate
    from any of the control functions capable of communicating
35 with the management part 43. If yes, then step S62 processes
    the update request, i.e. the updates requested are performed,
    e.g. one or more rules and one or more parameters are

changed. The procedure then continues to step S63, in which
it is determined whether an update request has been received
from the network control function (NCF) 51. If yes, then this
update request is processed in step S64. The procedure then
5   continues to step S65, in order to either loop back to the
beginning or to end.

As can be seen in the example of Fig. 6, the update requests
for the decision data that are received from the mobile node
10 (e.g. from the control function 50 at the mobile node) and
from the networks control function 51 are handled
independently of one another.

In the simple example shown in Fig. 6, both the mobile node
15 and the network control function have full access, i.e. can
update any rule or any parameter. However, it is also
possible that the management part 43 restricts the access of
one or both of the network control function and the mobile
node. For example, it is possible that the network control
20 function 51 receives full access, while the mobile node only
receives access to certain parameters and/or certain rules.
For example, the mobile node's access may be restricted to
parameters that indicate user preferences and rules for
"soft" decisions, but the mobile node does not receive any
25 access to rules for "hard" decisions (such as mandatory
handover decisions).

It is also possible that the access provided to different
control functions receives different priorities. An example
30 of this is shown in Fig. 7. The procedure of Fig. 7 starts
with step S71, in which it is determined whether an update
request has been received from the network control function
51. If this is the case, then the update request is processed
in step S72. Subsequent to step S72, a timer is reset in step
35 S73. The procedure then goes to step S74, in which it is
determined whether an update request has been received from a
mobile node. If this is the case, then step S75 determines

whether the timer has expired or not. Only if the timer has expired will the procedure proceed to step S76, in which the update request from the mobile node is processed. Otherwise, step S76 is skipped. The procedure then continues to step
5   S77, in order to either loop back to the beginning or to terminate.

Due to the use of the timer, the priority of the procedure is to process update request from the network control function
10   51, whereas update request from the mobile node (e.g. from the control function 50 of the mobile node) are only processed if sufficient time has passed since receiving the last update request from the network control function 51.

15   It is noted that the examples given in Figs. 6 and 7 use update requests as an interface for accessing the decision data memory. However, the invention is by no means restricted to such a technique, as the interface may be provided in any suitable or desirable way.
20
It is furthermore noted that the update requests received from the network control function 51 will typically be more frequent than those received from the mobile node. This again underscores the aspect of independent access, and indicates
25   one of the important advantages of the invention. Namely, by providing a plurality of independent control functions with access to the decision data memory, a highly flexible management of the decision data can be performed, e.g. in accordance with the possibly very different time scales
30   relevant for the individual control functions. It is also pointed out that the access to the decision data memory 42 by the two control functions 51 and 50 as shown in Fig. 4 is only an example, and any number of control functions may have independent access to the decision data via the management
35   part 43.

18

The decision part 41 and the decision procedure S51-S53 act
dynamically to select a forwarding address FA from the
decision data stored in decision data memory 42. Preferably,
this dynamic selection is such that it is performed for each
5   individual data unit to be forwarded. In other words, the
decision procedure preferably does not operate for a group or
block of data units at a time, but is performed individually
for each received data unit that it is to be forwarded.

10   Although the present invention has been described by way of
preferred examples, these only serve to convey to the skilled
person a more complete understanding of the invention, but
are by no means intended to be limiting. The invention is
defined by the appended claims, where the reference numerals
15   only serve to make the claims readable, but have no limiting
effect.